Space Weather Technical Forecast

Issued on Monday, 06 November 2023 at 01:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/G2 Minor/Moderate geomagnetic storms expected and chance of G3/Strong storming early 06 Nov due to ongoing CME influences. Chance of M-class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with two M-class flares originating from AR3480 in the southeast quadrant, the largest of which was a M1.8 at 05/1143 UTC. There are seven sunspot regions on the visible disc. AR3477 in the southeast is the largest region, it remains relatively stable, though it's large leader has become asymmetric in recent hours. AR3480 following shortly behind in the southeast appears more complex, with a Beta-Gamma magnetic arrangement. The remaining regions are either small and simple, or difficult to analyse, including AR3472 and AR3474 which are on or near the western limb, these spots were more complex during their transition across the solar disc and still appear as bright flux regions. No recent CMEs are thought to be be Earth directed.

Solar Wind / Geomagnetic Activity: Solar winds at L1, showed ongoing enhancement from 04 Nov CME arrival, as well as two further CME arrivals on 05 Nov. The first CME on 05 Nov is thought to be that which left the Sun on 02 Nov, this resulted in an increase of speeds to 420 km/s at 05/0813 UTC, followed by the larger CME from 03 Nov which resulted in an increase to 503 km/s at 05/1224 UTC, with a secondary peak of 533 km/s at 05/2225 UTC. Density was largely around average or slightly above during the early part of 05 Nov before rising to above average from 05/0810 UTC until the end of the period, with a peak of 64ppcc at 05/503 UTC. Total interplanetary magnetic field strength (IMF), Bt was initially moderate, before rising to strong from 05/0810 UTC with a peak of very strong, 44nT at 05/1152 UTC as the second of the two CMEs arrived at L1. The north south-component, Bz, had two prolonged strongly negative periods between 05/0833 UTC and 05/1802 UTC, with a peak of -27nT at 05/0858 UTC, though has declined or become positive toward the end of the period. Phi angle has been largely negative direction (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 2-3) initially before two G2/Moderate storm (Kp 6) periods from 0900 UTC, followed by two G3/Strong storm (Kp 7) periods from 1500 UTC, with a final G1/Minor Storm (Kp 5) period from 2100 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux eased from very slightly above base line due to the filament eruption on 03 Nov, to be at background. GOES16 high energy (greater than 2MeV) electron flux was background. The associated 24-hour fluence followed suit falling below the Active (1e8 integrated pfu) threshold from 05/1500 UTC, with a peak of 1.65e8 at 05/0000 UTC. The fluence observation at 06/0000 UTC was 1.09e6 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is expected, with chance of isolated M-class flares mainly from AR3480 in the southeast quadrant.

Solar Wind / Geomagnetic Activity: Following the CME arrival on 04 Nov, there were two further CME arrivals in the last 24 hours. Continued effects from these CMEs are expected to continue into 06 Nov. Solar wind speeds are expected to mostly ease through the 06 Nov, with a chance of further varied enhancements, perhaps back to strong. The next forecast enhancement will likely be of the high speed stream from coronal hole 67 late 06 Nov or 07 Nov. Elevated speeds would then be likely to persist into 08 Nov.

Geomagnetic activity is forecast to be around G1/Minor storm or G2/Moderate storm with a chance of isolated G3/Strong storms early on 06 Nov due to the recent CME arrivals. Activity is likely to ease later 06 Nov and possibly into 07 Nov, but this may be then enhanced due to the onset of the high speed stream from coronal hole 67, possibly giving further G1/Minor Storm intervals late 06 Nov or on 07 Nov. No further geomagnetic storms are expected from 08 Nov.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to persist at background levels. High energy electron flux (greater than 2MeV), is likely to slowly recover towards Moderate or High after CME effects and the CH HSS ease later in the period. Associated 24-hour electron flux, may become enhanced toward the end of the period as the CH HSS eases, though timings on this occurring is considered to be low confidence.

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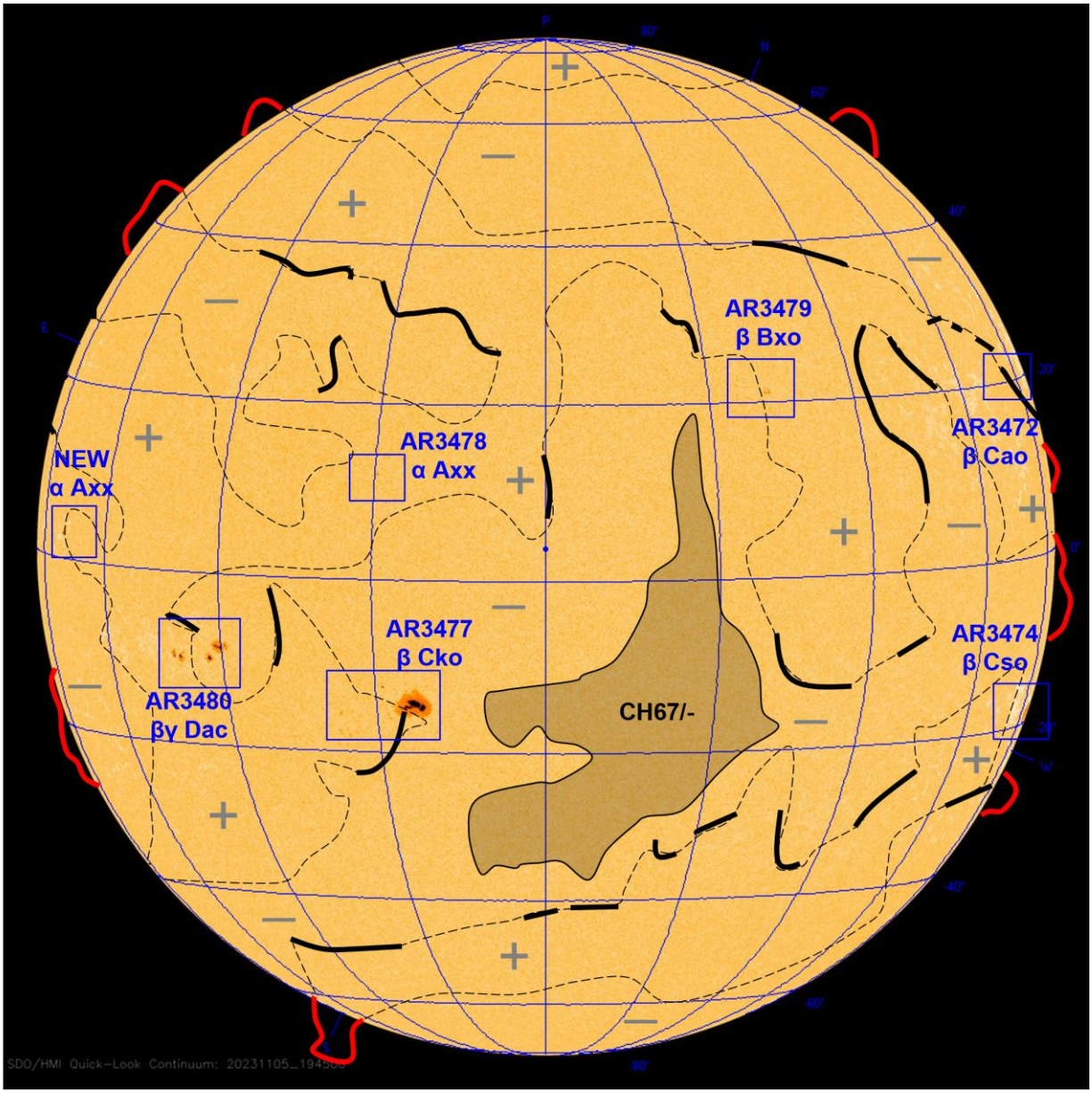
Figure 1. Solar Analysis Valid 05/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Following the CME arrival on 04 Nov, there were two further CME arrivals in the last 24 hours, the first was from a CME which left the northeast of the disc 02/0230 UTC, the second from an eruption at 03/0430 UTC.

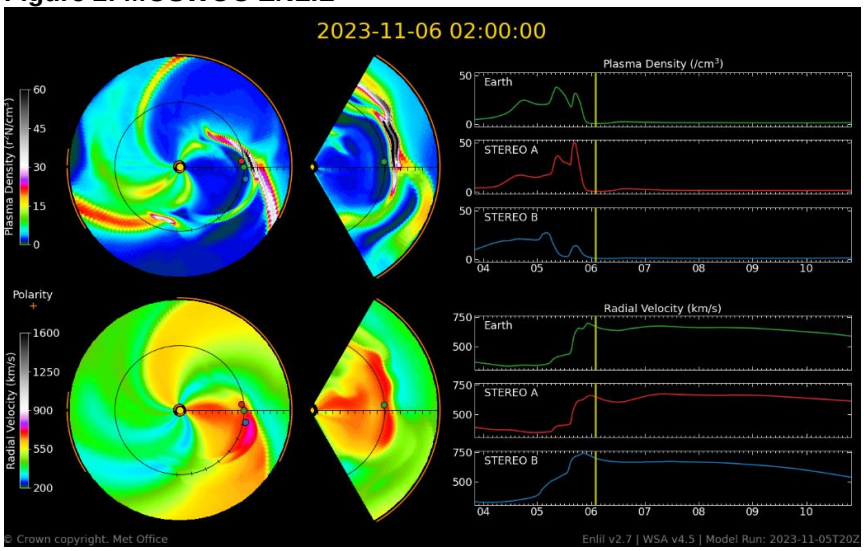
This last arrival is the fastest of the three CMEs due to arrive at Earth and as a large, dense filament is expected to have continued and varied effects into 06 Nov.

Solar wind speeds are expected to mostly ease through the 06 Nov, but speeds may become enhanced to 500-550 km/s. These speeds should then gradually decline during 06, prior to the arrival of the high speed stream from coronal hole 67 late 06 Nov or 07 Nov, based on speeds of 600 km/s, although these are an estimate with no persistence or observations to rely on. Elevated speeds would then be likely to persist into 08 Nov.

Geomagnetic activity is forecast to be around G1/Minor storm or G2/Moderate storm with a chance of isolated G3/Strong storms early on 06 Nov due to the recent CME arrivals. Due to the nature of the lingering effects of these CMEs there remains some uncertainty to the longevity of their effects. Activity is then likely to ease later 06 Nov and possibly into 07 Nov, but this may be then enhanced due to the onset of the high speed stream from coronal hole 67, possibly giving further G1/Minor Storm intervals late 06 Nov or on 07 Nov. No further geomagnetic storms are expected from 08 Nov.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	70	40	20	10
Strong	G3	No	30	1	1	1
Severe	G4	No	5	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC ENLIL



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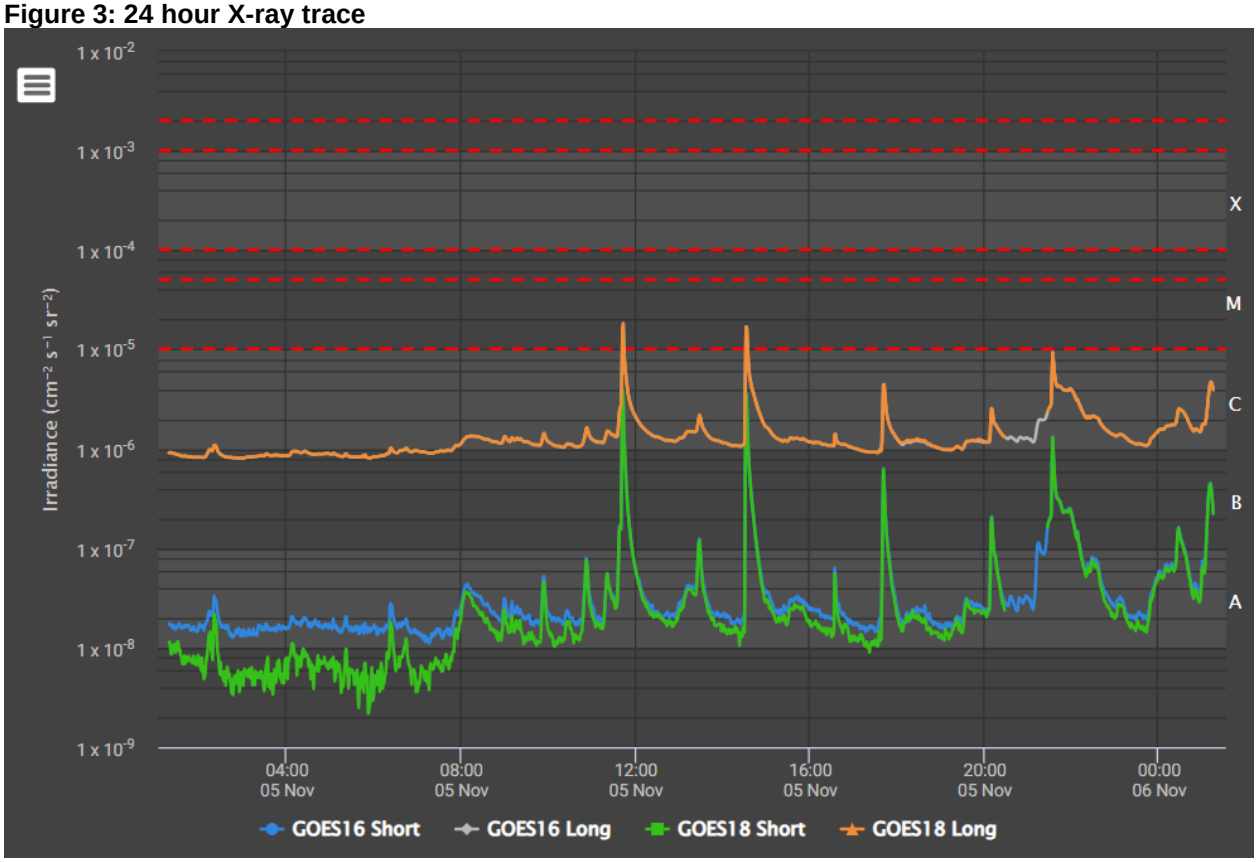
Radio Blackouts - X-Ray Flares:

Low activity is expected throughout the forecast period with a chance of Moderate activity due to isolated M-class flares, mainly from the two complex regions in the southeast, but also due to AR3474 and AR3742 on or near the western limb, though this risk reducing through day 1 (06 Nov) and beyond as the two spots on the western limb rotate completely out of view.

There are seven sunspot regions on the visible disc. AR3477 in the southeast is the largest region, it remains relatively stable, though it's large leader has become asymmetric. AR3480 following shortly behind in the southeast appears more complex, with a Beta-Gamma magnetic arrangement. The remaining regions are either small and simple, or difficult to analyse, including AR3472 and AR3474 which are on or near the western limb, these spots were more complex during their transition across the solar disc and still appear as bright flux regions. The remaining regions are either small or developing slowly.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	40	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: 24 hour X-ray trace



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at mainly background levels. The main source of any enhancement is likely to be from any filament eruptions or from any more significant flares. These are most likely to effect the Earth if originating from the western disc, with a slightly increased risk by the end of the period as the larger and more complex sunspots traverse into the hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour Proton Trace

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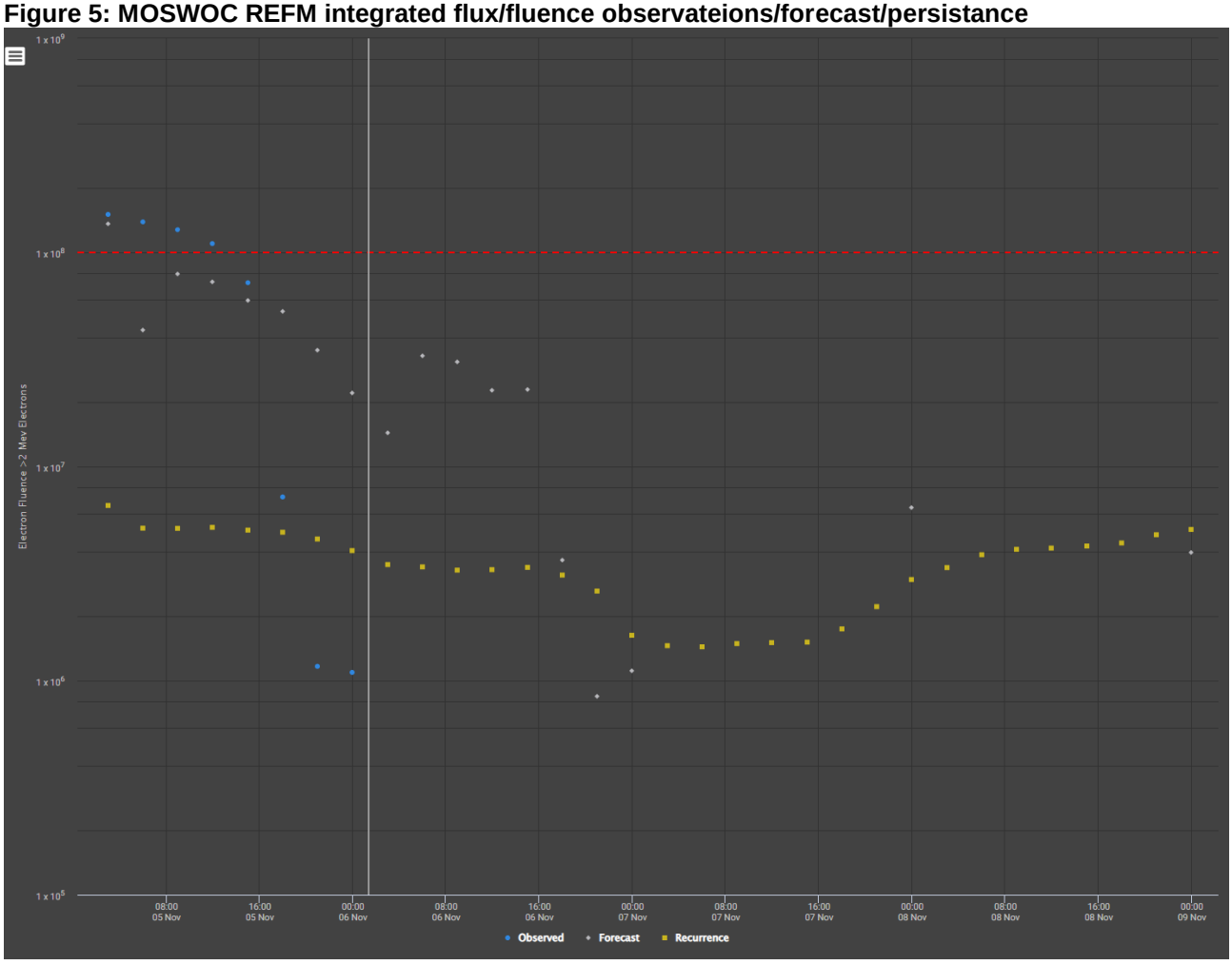
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed at GOES16 has dropped to background levels due to the recent CME arrivals. After the CME effects and the CH HSS ease later in the period, the electron flux is likely to slowly recover towards Moderate or High.

Associated 24-hour electron flux, may become enhanced toward the end of the period as the CH HSS eases, though timings on this occurring is considered to be low confidence. The MOSWOC REFM model is considered to be giving good guidance at present.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	1	20	20	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM integrated flux/fluence observateions/forecast/persistance



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